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14. ABSTRACT

The workshop was intended to cover the significant experimental progress in the field of two-dimensional electrons that in recent years has led to a wave of new discoveries and has stimulated an impressive theoretical effort. Among them it is worth to mention the observation of novel correlated states and superfluidity in bilayer systems, research on electronic liquid-crystal states in high Landau levels, the radiation-induced zero-resistance states in very low magnetic fields, the discovery of quantum Hall effect in graphene layers and of the quantum spin-Hall effect, and finally proposals and experiments on quantum computing with non-abelian quantum Hall states. These novel emergent fields of research are attracting a large interest of the condensed-matter community. This frontier Symposium EPQHS-3 was intended to bring together a team of leading scientists and young researchers working on these emergent collective electronic states in solids with the goals to focus on the intriguing and exciting new directions outlined above, to review the status of current research and establish new collaborations.
The conference had about 70 participants with a large fraction being PhD students and young researchers. There were 26 invited presentations and 18 posters. Many invited talks were given by young researchers (both PhD and post-docs). A list of invited speakers and the topics is included.

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Emergent Phenomena in quantum Hall systems EPQHS-3: Final report

Introduction

The workshop Emergent Phenomena in quantum Hall systems was held in Matraia (Lucca-Italy) on 25-28 June 2009. It was the third edition of the EPQHS workshop series that started in 2005. Previous editions were held in Taos (New Mexico) in July 2005 and in Penn State University in June 2007. EPQHS-4 will be held in Beijing on 23-26 June 2011.

The scientific committee was composed by

Jim Eisenstein (Caltech, Pasadena, CA, USA)
Sankar Das Sarma (University of Maryland, College Park, MD, USA)
Jainendra Jain (Penn State University, University Park, PA, USA)
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Steve Simon (Rudolf Peierls Centre for Theoretical Physics, Oxford, UK)

The workshop EPQHS-3 was supported by the National Enterprise of nanoScience and nanoTechnology (NEST) at Scuola Normale Superiore, by Banca Monte dei Paschi di Siena, by the National Science Foundation (NSF), the Office of Naval Research (ONRIFO), and the European Office of Aerospace Research & Development (EOARD).

An EPQHS-3 book of abstracts was realized. The preface of this booklet acknowledges support from EOARD. A web page was created at the following address: http://epqhs3.sns.it/home.shtml

Goal of the workshop and scientific program

The workshop was intended to cover the significant experimental progress in the field of two-dimensional electrons that in recent years has led to a wave of new discoveries and has stimulated an impressive theoretical effort. Among them it is worth to mention the observation of novel correlated states and superfluidity in bilayer systems, research on electronic liquid-crystal states in high Landau levels, the radiation-induced zero-resistance states in very low magnetic fields, the discovery of quantum Hall effect in graphene layers and of the quantum spin-Hall effect, and finally proposals and experiments on quantum computing with non-abelian quantum Hall states. These novel emergent fields of research are attracting a large interest of the condensed-matter community.

This frontier Symposium EPQHS-3 was intended to bring together a team of leading scientists and young researchers working on these emergent collective electronic states in solids with the goals to focus on the intriguing and exciting new directions outlined above, to review the status of current research and establish new collaborations.

The conference had about 70 participants with a large fraction being PhD students and young researchers. There were 26 invited presentations and 18 posters. Many invited talks were given by young researchers (both PhD and post-docs). This is a list of invited speakers and the topics covered:

1) E. Andrei (Rutgers, USA) Imaging of Landau levels in Graphene
2) F. Burnell (Princeton, USA) Quantum computation with abelian states
3) A. R. Champagne (Caltech, USA) Superfluidity in electron double layers
4) O. Dial (MIT, USA) A new quasiparticle revealed by a sc
5) M. Dolev (Weizmann, Israel) Measurements of fractional charges in the 5/2 quantum Hall states.
6) A. E. Feiguin (Microsoft, USA) Topological quantum computation
7) H. Fertig (Indiana University, USA) Quantum Hall effect in graphene
8) G. Gervais (McGill, Canada) Activation gap of the 5/2 state in tilted magnetic fields
9) T. Gokmen (Princeton, USA) Spin and Valley degree of freedoms in AlAs quantum wells.
10) Z. Hadzibabic (Cambridge, UK) Quantum Hall physics with cold atoms
11) E. A. Henriksen (Columbia University, USA) Cyclotron resonances in graphene
12) B. Karmakar (NEST Pisa, Italy) Quantum phase transitions in quantum Hall bilayers
13) V. S. Khrapai (Institute of Solid State Physics RAS, Russia) Energy gaps in the fractional quantum Hall regime
14) K. Von Klitzing (MPI, Germany) Magneto-rotons in the quantum Hall fluids
15) A. H. MacDonald (University of Texas at Austin, USA) Ferromagnetism and superfluidity in graphene
16) L. Molenkamp (Wuerzburg, Germany) The quantum spin-Hall effect
17) R. Morf (Paul Scherrer Institute, Switzerland) Non-abelian states in the quantum Hall regime
18) K. Muraki (Tokyo U., Japan) Spin transitions in quantum Hall bilayers
19) M. Peterson (Maryland, USA) Particle-hole symmetry and the 5/2 state
20) M. Potemski (Grenoble, France) Far-infrared measurements in graphene and graphite
21) M. Sassetti (Genova, Italy) Inter-edge tunneling of fractionally-charged quasiparticles
22) L. Tiemann (MPI, Germany) Corbino geometries in quantum Hall bilayers
23) C. Tőke (Lancaster, UK) Fractional quantum Hall effect in graphene
24) D. Tsui (Princeton, USA) Quantum criticality in the quantum Hall regime
25) W. Wegscheider (Regensburg, Germany) Perspectives for ultra-high mobility semiconductor heterostructures
26) K. Yang (NHMFL, USA) Non-abelian quasiparticle statistics in fractional quantum Hall liquids

Short summary of key talks presented at EPQHS-3.

Several contributions were given on the topic of the nature of the fractional quantum Hall states in the second Landau levels, such as the 5/2 state, and prospects of topological quantum computing. New results on the quasiparticle charge and quasiparticle tunneling effects were shown by Merav Dolev of the

Weizmann Institute (Israel) and Iuliana Radu of MIT (USA) while new theoretical concepts and proposals for quantum computation based on fractional quantum Hall states were discussed by Michael Peterson University of Maryland (USA), Rudolf Morf of ETH (Switzerland), Roni Ilan at Weizmann Istitute (Israel), and Adrian Feiguin of the Univ. of Maryland (USA). In his talk, Werner Wegscheider from ETH (Switzerland) offered a review of the present status and future prospects of MBE growth of ultra high-mobility two-dimensional electron gases in semiconductor heterostructures.

Trevor D. Rhone from Columbia University (USA) and Klaus Von Klitzing at the MPI (Germany) have presented recent experimental results on the collective excitations in the fractional quantum Hall regime while the most intriguing optics and transport results on quantum Hall bilayers were presented by Biswajit Karmakar from NEST (Italy), Koji Muraki from NTT (Japan) and Alexandre Champagne from Caltech (USA). Tayfun Gokmen from Princeton University (USA) discussed transport studies of composite fermion physics in AlAs systems with double valley occupation. Daniel C. Tsui form Princeton University (USA) discussed the long-standing issue of quantum critical behavior of the plateau-plateau transition.

A large part of the workshop focused on graphene and in particular its behavior at high magnetic fields. During the graphene session Eva Andrei from Rutgers University (USA) reported the first observation of the fractional quantum Hall effect in high quality suspended graphene layers. Marek Potemski from Grenoble (France) offered a comprehensive review of magneto-optical spectroscopy of Dirac fermions in graphene and graphite. On the theory side we heard from Allan MacDonald of the University of Texas (USA) about the theoretical possibility of excitonic superfluidity in graphene bilayer while Herb Fertig from Indiana University (USA) discussed the structure of the edge states in graphene at filling factor 0.

Finally other emerging topics were covered in the scientific program such as the spin-Hall phenomena in the insulating states of HgTe structures by Laurens Molenkamp form Wurzburg University (Germany) and the possibility to have fractional quantum Hall states in bulk isotropic materials. This last topic was covered by Fiona Burnell of Princeton University (USA).

In addition to keynote speakers, several contributed poster presentations mainly from young researchers from Europe, Japan and United States have further shown the rich physics associated to diverse emerging fundamental effects in the quantum Hall regime.

The structure of the workshop's program with several periods of time left for free discussions and its location (an old villa in the hills close to the city of Lucca) have favored the interaction among the participants. While the research topics debated at the EPQHS-3 Conference are largely linked to contemporary fundamental and applied condensed matter science, it is important to highlight that the event brought together prominent scientists and junior researcher from the US, Europe and Japan. In my opinion the meeting has fostered collaborations with a global reach.